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Policy Challenges to China's Shale Gas Industry

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Report

Presented to the Faculty of the Graduate School of

The University of Texas at Austin

in Partial Fulfillment

of the Requirements

for the Degree of

Master of Arts

and

Master of Global Policy Studies

The University of Texas at Austin

May, 2016

Abstract

Policy Challenges to China's Shale Gas Industry

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The University of Texas at Austin, 2016

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As a result of China's significant position in the petroleum market, contributions to greenhouse gas emissions, and domestic pollution, Chinese policy makers and industry leaders are increasingly highlighting China's vast reserves of shale gas. Although there is growing production of shale gas in China's Sichuan Basin, China's state targets for shale gas development are still unmet. Thus, this work analyzes China's shale gas policy, which is implemented through tools such as the petroleum sharing agreement, tax regimes, pipeline access, pricing system, regulatory structures, and international programs. Data in this paper is derived from published reports by industry experts. In addition, I carried out 10 expert interviews for this project, with interviews in Houston and by telephone. This paper evaluates specific qualities that attract shale gas investment and reinforce a mutualistic relationship between petroleum companies and the government, and judges the qualities that harm this relationship and are hindering shale gas development. For example, China's use of the sliding scale royalty, support for joint ventures, and research and development programs contribute to shale gas development. However, possible hindrances

to China's shale gas revolution include the production sharing agreement structure, the monopolization of conventional reserves by China's national oil companies, the lack of competitive pipeline access, the unclear and excessive overlap of regulatory agencies, and several environmental concerns related to hydraulic fracturing. As a result, China's shale gas revolution will likely be led by its National Oil Companies for the near future.

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INTRODUCTION

The People's Republic of China is among the world's largest oil and gas producers, ranking fourth in global crude oil production and sixth in natural gas output.[1] China's national oil companies (NOCs) –China National Petroleum Company (CNPC) and its publicly listed arm, Petrochina; Sinopec; China National Offshore Oil Corporation (CNOOC); and to a lesser extent Shaanxi Yanchang Petroleum – dominate China's petroleum production, transportation, and marketing.[2] Smaller firms such as Sinochem, Citic China, and several provincial companies are also active in China's petroleum industry but are excluded from the upstream.

As the world's most populous country and a fast-growing economy, China's consumption of petroleum products is rising at a rate faster than its production, resulting in dependency on foreign supplies. Because a majority of China's crude oil and liquefied natural gas imports pass through the narrow Strait of Malacca, China's petroleum supplies are exposed to geopolitical risk.[3] This risk not only exposes the NOCs' supply chains but also threatens China's promised economic growth and social stability. Additionally, China's recent pollution epidemic and contributions to global warming are piquing the leadership's and industry's interests in the country's vast, underdeveloped shale gas

[1] International Energy Agency, "Key World Energy Statistics" *International Energy Agency*. 2014.
[2] Feng, Hongli. "2015 nian zhongguo yeyanqi kaifa zuixin jinzhan baogao 年中国页岩气开发最新进展报告 [2015 Report on New Progress in China's Shale Gas Development]." *CNENERGY*. May 8, 2015. http://www.cnenergy.org/yq/fcg/201505/t20150508_37088.html; Ding, Chen and Julie Jiang, "Update on Overseas Investments by China's National Oil Companies." *International Energy Agency.* 2014.
[3] Zhang, Zhongxiang. "China's Energy Security, the Malacca Dilemma and Responses." *Energy Policy* 29 (12): 7612-7615. 2011.

reserves. Observing the United States' shale gas revolution, the Chinese leadership hopes to similarly fuel switch from coal to cleaner natural gas.[4]

As a result, China is implementing policies through its national contractual systems, fiscal regimes, and regulatory structures to promote domestic shale gas development. Although China's leadership is successful in developing a stable, international petroleum industry within only a few decades, several of China's policies towards its shale gas market discourage industry expansion or endanger the crucial relationship between the companies and the government.

[4] Calow, Roger, Vanessa D'Alancon, Julian Doczi, Ilmi Granoff, Zhenbo and Sam Pickard. "Can Fracking Green China's Growth." *Overseas Development Institute.* 2015.

CHINESE SHALE GAS RESERVES

Shale reservoirs refers to petroleum trapped in fine-grained shale sedimentary rock formations. Unlike conventional reservoirs where petroleum can freely move through interconnected pore spaces, similar to a sponge, shale reservoirs have low permeability which limits the flow of petroleum to the well. To create additional permeability and extract resources out of the shale, a high pressure fluid containing sand or another gritty proppant is injected into the wellbore to create artificial fractures through which natural gas and oil will flow smoothly. Typically, resource abundance in a shale reservoir is low, however shale reserves are widespread and located throughout China, making this a valuable asset.[5]

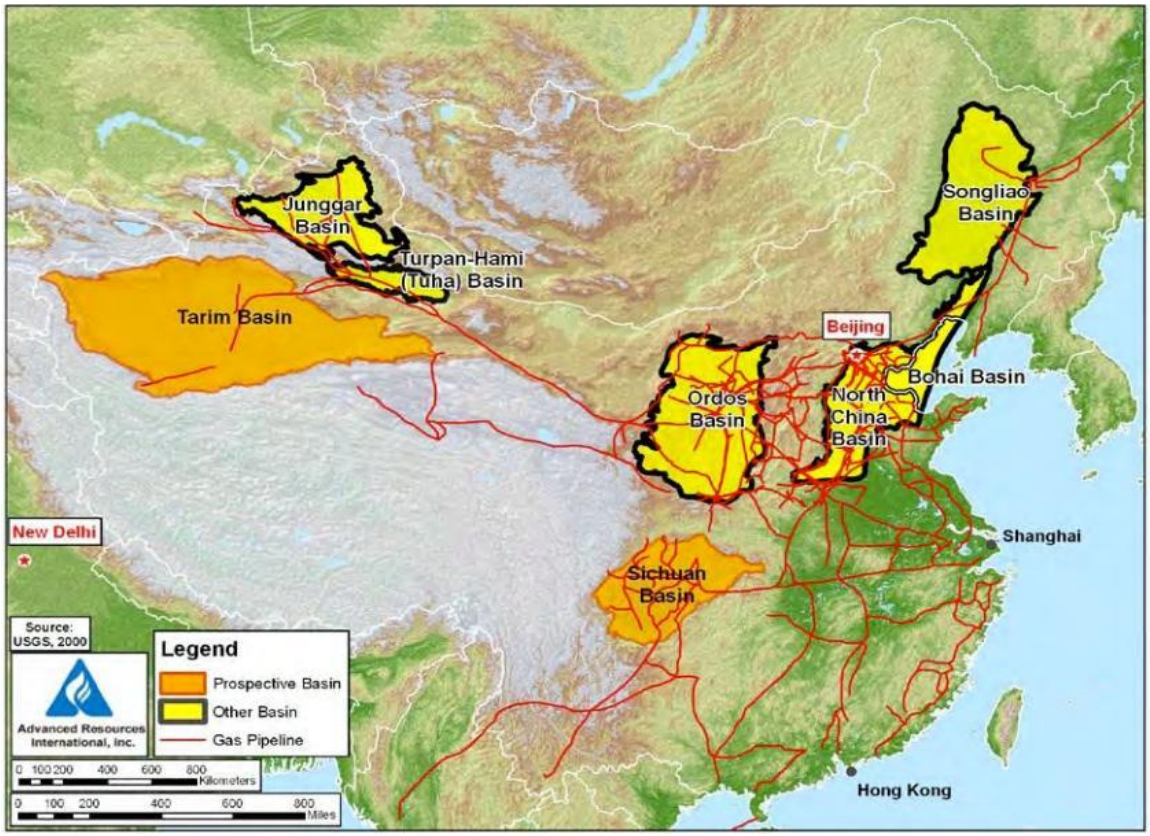
China possesses the largest shale gas reserves in the world with 1,115 trillion cubic feet (Tcf) of technically recoverable shale gas[6] –nine times greater than China's conventional gas reserves.[7] Depicted in Figure 1, most of China's shale gas is deposited in the Sichuan Basin (626 Tcf), with additional reserves located in the Tarim (216 Tcf), Junggar (36 Tcf), Songliao (16 Tcf) basins. Most of China's shale projects are located in the Sichuan Basin, not only because of its vast shale gas reserves, but also because of access to water which is consumed during hydraulic fracturing.[8] However, Yanchang Petroleum is now investing in the drier Ordos Basin.[9] China's shale gas reserves are in more

[5] Chen, Weidong, Jiang Xi-men and Zhou Xiaolai. "China's Shale Gas: Current Prospectives." *Nautilus Institute for Security and Sustainability.* 2014.
[6] Technically recoverable reserves represents the volume of shale gas that can be produced with current technology, regardless of natural gas prices and production expenditures.
[7] Calow et al., *op. cit*.
[8] U.S. Environmental Information Agency. "Technically Recoverable Shale Oil and Shale Gas Resources: An Assessment of 137 Shale Formations in 41 Countries Outside the United States." 2013.
[9] Feng, *op. cit.*

complicated formations than their U.S. counterparts. Reserves in the Sichuan Basin are as deep as 4500 meters, compared to the Marcellus (2134 meters) and the Eagle Ford (3505 meters) formations.[10] Deeper formation depth not only increases the exploration difficulties but also heightens extraction costs. In China it costs roughly 20,000 RMB/meter to drill a vertical well.[11] Sichuan's reserves are also only 33 to 52 meters thick, half as thick as their U.S. equivalent, making it more difficult for producers to drill horizontally into the formation. Furthermore, Sichuan's shale formations have low porosity, thus requiring greater quantities of fracking fluid to stimulate production, and exhibit geological folding which complicates well productivity.[12]

[10] U.S. Trade and Development Agency. "China Shale Gas Development and Technologies Reverse Trade Mission." November 24, 2014.
[11] Chen et al., *op. cit.*
[12] U.S. Trade and Development Agency 2014, *op. cit.*

Figure 1: Shale Gas Basins and Pipeline Infrastructure in China[13]



China's leadership sets high targets for its shale gas production. In the 12th Five-Year Plan (FYP), China planned to double natural gas in primary energy consumption from 4 percent in 2013 to 8.3 percent by 2015. Specifically, shale gas production targets are set at 6.5 billion cubic meters (bcm) of production per year, 990 horizontal wells drilled by 2015, and 60-100 bcm of production per year by 2020.[14] In 2014, however, China's 2020 targets were curtailed to 30 bcm per year. Of the 30 bcm producer per year, 25 bcm will

[13] Advanced Resources International. "World Shale Gas Resources: An Initial Assessment." 2011.
[14] Forbes, Sarah. "The United States and China: Moving toward Responsible Shale Gas Development." *Brookings Institution.* 2013.

come from the Sichuan Basin alone.[15] Furthermore, as of December 2015 China's annual production is 5.1 bcm/year, failing to meet 6.5 bcm/year target.[16]

The 13th FYP (2016-2020) also cites shale gas development as a strategic goal and indicates government support for 58 shale gas projects, naming Sichuan Changning, Chongqing Fuling, Yunan Zhaotong, Shaanxi Yanan, and Guizhou Zunyi as major development sites.[17] The government has yet to update its production quantity goals - however, industry experts expect a 50 bcm/year target for the 13th FYP, which indicates renewed yet limited optimism in the shale gas industry.[18] Although the reduction in China's 2020 shale gas targets from 100 bcm/year cites technical and economic obstacles, China's shale contracts and regulations are also root causes.

CURRENT SINO-FOREIGN JOINT VENTURES

Although foreign companies are not allowed to independently explore, develop, or produce petroleum products in China, their involvement in NOC joint ventures is actively encouraged. In October 2007, Newfield Exploration and PetroChina entered into China's

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[15] Calow et al., *op. cit*.

[16] Sung, Manchu. "Sinopec Plans to Boost Giant Shale Gas Projects, as China Set to Miss 2015 Shale Targets." *Oil Pro.* 2016. http.//oilpro.com/post/21170/Sinopec-hopes-to-double-annual-production-capacity-2017-giant-sha.

[17] National Development and Reform Commission. "Zhonghua renmin gongheguo guomin jingji he shehui fazhan di shisan ge wunian guiji gangyao 中华人民共和国国民经济和社会发展第十三个五年规划纲要 [Outline of the 13th Five Year Plan on the Economic and Social Development of the People's Republic of China]". March 2016. http://www.sdpc.gov.cn/gzdt/201603/P020160318576353824805.pdf.

[18] Lu, Donghou. "Feichanggui de 'shisanwu' jiyu 非常规的'十三五'机遇 [The 13th Five Year Plan's Opportunity for Unconventionals]". March 30, 2016. http://www.agoil.cn/zhuanti/gas-shales/2016-03-30/9243.html.

first NOC shale gas joint venture project in Sichuan Province's Weiyuan Field.[19] As seen in Table 1, several International Oil Companies (IOCs) are now working alongside Chinese NOCs in shale gas exploration, development, and production. However, the recent decline in international petroleum prices has limited IOC investment in Chinese shale gas. Due to low prices and high costs, Hess has exited completely from China's upstream industry.[20] Similarly, Shell has indicated it will no longer pursue the development of the Fushun-Yongchuan shale gas block in Sichuan.[21] However, BP signed its first PSA with CNPC in April 2016, building upon the framework agreement on strategic cooperation signed last October during President Xi Jinping's visit to the U.K. Under the framework agreement, in the future BP can extend its China joint ventures to not only other shale gas projects, but also to fuel retailing, oil exploration, LNG trading, and carbon emissions trading. [22] Significantly, unlike previous agreements between IOCs and Chinese NOCs, under this PSA CNPC will act as the operator while BP only contributes technical expertise and financial capital. [23] CNPC's designation as operator indicates a growing recognition of the NOCs' abilities as shale gas producers.

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[19] Lou, Ying and Wang Ying. "PetroChina Longgang May Be Nation's Largest Gas Field." 2008. *Bloomberg*. http://www.bloomberg.com/apps/news?pid=newsarchive &sid=af3t9d7hr7t8.
[20] Xu, Yihe. "Hess Quits all E&P Activities in China." *Upstream*. December 18, 2015. http://www.upstreamonline.com/live/1419657/hess-quits-all-eandp-activities-in-china.
[21] Khawar, Muhammad Ali. "Royal Dutch Shell Limiting Investment in Chinese Shale Gas." Bidness Etc. April 3, 2016. http://www.bidnessetc.com/66543-royal-dutch-shell-limiting-investment-chinese-shale-gas/.
[22] Eurasia Review. "BP and CNPC Sign Shale Gas Production Sharing Contract in China." April 5, 2016. http://www.eurasiareview.com/05042016-bp-and-cnpc-sign-shale-gas-production-sharing-contract-in-china/.
[23] Guo, Aibing. "BP Taking a Bet on China's Shale Gas While Shell Backs Out." *Bloomberg*. April 1, 2016. http://www.bloomberg.com/news/articles/2016-04-01/bp-taking-a-bet-on-china-s-shale-gas-while-shell-backs-out.

Table 1: IOC Shale Gas Projects in China to Date[24]

Entrance Time	IOCs	NOCs	Location	Work Commitment and Status
Oct 2007	Newfield Exploration	PetroChina	Weiyuan Field (Sichuan Province)	Completed in 2008
Nov 2009	Shell	CNPC	Fushun-Yongchuan Block (Sichuan Province and Chongqing Municipality)	Started joint production in Mar 2012
Jan 2010	BP	Sinopec	Kaili Block (Guizhou Province); Huangqiao Block (Jiangsu Province)	Ongoing
Mar 2010	Shell	CNPC	Jinqui Block (Sichuan Province)	30-year PSA on tight gas
Jul 2010	Hess Corp.	Sinopec	Shengli Oil Field (Shandong Province)	Hess has exited China upstream.
Mar 2011	Total	CNPC	Sulige South, (Inner Mongolia)	Began production in May 2012
Apr 2011	Chevron	Sinopec	Qiannan Basin (Guizhou Province)	Seismic; two exploratory wells, both were unsuccessful.
Jul 2011	ExxonMobil	Sinopec	Wuzhishan-Meigu Block (Sichuan Province)	Ongoing
Mar 2012	Total	Sinopec	Anhui Province	No details
Jun 2012	Shell	Sinopec	Hunan, Hubei, and Jiangxi Provinces	Seismic and 2-3 wells

[24] Hove, Anders, Junda Lin, David Sandalow, Jingchao Wu and Qing Yang. "Guanyu shixian zhongguo yeyanqi mubiao de jianyi 关于实现中国页岩气目标的建议[Meeting China's Shale Gas Goals]." Columbia School of International and Public Affairs. 2014; Chou, Ella. "Shale Gas in China-Development and Challenges." 2013; EIC Monthly. "Shell Expands Presence in China's Shale Gas." Page 21. 2013; and Eurasia Review, *op. cit.*

Table 1 (continued)

Dec 2012	ConocoPhillips	Sinopec	Qijiang (Chongqing Municipality)	Seismic and two wells
Dec 2012	Baker Hughes	Honghua Group	Research center in Chengdu, Sichuan Province	Research on shale gas exploration, development and production. Ongoing
Dec 2012	ConocoPhillips	CNPC	Neijing-Dazu, (Sichuan Province and Chongqing Municipality)	Joint Study Agreement, abandoned in 2014.
Mar 2013	Eni	CNPC	Rongchang Block (Sichuan Province and Chongqing Municipality)	Joint Study Agreement, Ongoing
July 2013	Hess Corp.	CNPC	Xinjiang Uyghur Autonomous Region	Hess has exited China upstream.
Sep 2013	Shell	Hunan Huasheng Energy Resources and Valin Iron & Steel	Longshang Block (Hunan Province)	No Details
Apr 2016	BP	CNPC	Neijiang-Dazu Block (Sichuan Province and Chongqing Municipality)	PSA signed with CNPC as operator.

Shale gas development typically requires large amounts of sunk investments in drilling and hydraulic fracturing. In the United States, shale gas innovation was driven by Mitchell Energy, a large and diversified gas producer. As drilling technologies and practices were proven cost-effective, smaller firms then entered the market and scaled up

production.[25] As seen in table 6, most shale gas IOC-NOC joint ventures are operated by China's giants CNPC and Sinopec. With the backing of these two large firms, these projects have the financial and technical capacity to make such investments. Additionally, Chinese NOCs are increasingly offering stakes in domestic shale projects to IOCs in return for NOC participation in foreign unconventional oil and gas, liquefied natural gas, or deep-water projects. This mutually beneficial cooperation attracts companies to China and globalizes China's NOCs. For example, in 2013 CNPC concluded a deal with Italy's Eni and became the first Chinese NOC to enter one of Mozambique's offshore Rovuma gas field. Eni planned to reduce its funding commitment to the project and find a potential customer for its East African LNG exports. As for CNPC's incentives, Eni signed a co-operation agreement for shale gas exploration in Sichuan province's Rongchang block. This form of asset swap is now an unspoken rule for IOCs to operate in China.[26] Small, domestic Chinese firms are involved in the shale gas market, but lack the connections and experience to engage in asset swapping. Furthermore, as explained below, they are significantly constrained by the legal contracting process.

[25] Krupnick, Alan, Xiaoli Liu, Lei Tian and Zhongmin Wang. "Stimulating Shale Gas Development in China." Resources for the Future. 2014.
[26] Ding and Jiang, *op. cit.*

THE PETROLEUM SHARING AGREEMENT

China's shale gas contract utilizes the same structure and obligations as its conventional oil and gas contract. It is a hybrid agreement that incorporates aspects of a concession/royalty agreement into a production sharing agreement (PSA). Individual cases might also include joint venture agreement clauses if the Chinese oil company is working alongside a foreign NOC or IOC. In order to protect state assets, foreign participants are legally restricted to a minority partnership in any Chinese NOC upstream joint venture, but may act as the project operator.[27] Within a joint venture, each investor's share of operating expenses and revenues -their respective working interest and net revenue interest- are then determined before signing the contract.[28]

Shale blocks are distributed by the Ministry of Land and Resources through auction bidding, where minimum exploration work, minimum expenditures, and the production sharing terms are the major bidding variables. Upon acceptance of the contract, the petroleum company then offers an up-front payment (signature bonus) to the Ministry of Land and Resources.[29] The use of a signature bonus is common in several countries and motivates the company to begin production earlier to generate a return on their investment.[30] The signature bonus also immediately provides revenues to the government agency, while the revenues from a reserve-based or production-based bonus are long-term and negatively impacted by inflation. The signature bonus, unlike a reserve-based bonus,

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[27] Ministry of Commerce of the People's Republic of China. "Waishang touzi chanye zhidao mulu 外商投资产业指导目录 [Guiding Catalogue for Foreign Investment Industries]." 2002. http://wzs.mofcom.gov.cn/article/n/200208/20020800035372.shtml.

[28] Inkpen, Andrew and Michael Moffett. The Global Oil & Gas Industry, 214-253. Tulsa, Okla: PennWell. 2011.

[29] AUPEC Ltd. "Evaluation of the Petroleum Tax and Licensing Regime of New Zealand." 2009.

[30] Inkpen and Moffett, *op. cit.*

disadvantages smaller shale gas companies because they are less capable of financing the up-front payment.

ROYALTIES AND RESOURCE TAX

The first portion of a Chinese shale gas contract is the concession/royalty agreement if the contract was signed before 1 November 2011. Because the Chinese government owns the rights to all mineral resources, the government permits the company to produce and sell the shale gas in exchange for a royalty payment. The gas royalty is essentially a production tax. The royalty is paid in-kind with the natural gas produced at rates published by the Ministry of Finance. The rates are set at different levels subject to the location of the project. Table 2 demonstrates that Chinese offshore projects and on-shore operations in Qinghai, Tibet, and Xinjiang (locations with higher costs and less access to infrastructure) are subject to lower royalty rates when the project is small.[31]

Table 2: Sino-Foreign Gas Royalties in Qinghai, Tibet, Xinjiang and Offshore[32]

Annual Gross Output of Natural Gas (Cubic Meters)	Royalty Rate
Portion not exceeding 2 billion	0%
Portion between 2 billion and 3.5 billion	1%
Portion between 3.5 billion and 5 billion	2%
Portion exceeding 5 billion	3%

[31] Ernst & Young. "EY Oil and Gas Tax Guide." 2015. http://www.ey.com /Publication/vwLUAssets/EY-2015-Global-oil-and-gas-tax-guide/$FILE/EY-2015-Global-oil-and-gas-tax-guide.pdf.
[32] *Ibid.*

Shale gas operations in any other Chinese province are subject to a different set of royalties as detailed in Table 3. These projects are subject to higher rates when production remains under 2 billion cubic meters of natural gas a year.

Table 3: Sino-Foreign Onshore Gas Royalties (All Other Provinces)[33]

Annual Gross Output of Natural Gas (Cubic Meters)	Royalty Rate
Portion not exceeding 1 billion	0%
Portion between 1 billion and 2.5 billion	1%
Portion between 2.5 billion and 5 billion	2%
Portion exceeding 5 billion	3%

On contracts signed before 1 November 2011, China applies a sliding scale royalty.[34] Typically, a higher, locked-in royalty will prevent further development and efficient production from the project because higher costs from royalty rates will reduce the field's economic life. However, China's sliding scale royalty implements a higher royalty rate when the production of the field is high, and a lower royalty rate when production declines. Thus, when production falls, the company has more capital available to exploit the field or for exploration and development elsewhere in the region, while the government also benefits from a longer term of fiscal revenues.

After the State Council enacted the New Sino-Foreign Cooperative Exploration Regulations, petroleum agreements entered after 1 November 2011 do not include these

[33] *Ibid.*
[34] *Ibid.*

royalty regimes.[35] However, no clarification has been made if the 1 November 2011 cut-off date refers to the signing date or the effective date of the contract.[36] Instead, shale gas companies are liable to pay a resource tax, which is a system similar to the previous royalty system. Under the new system, the average tax rate for natural gas is set at 6%, is based on the sales price rather than sales volume, and will eventually be raised to 10%.[37] However, preferential tax rates are available for high sulfur gas extraction, tertiary recovery, and low abundance fields. These tax reductions emulate the attractive qualities of the scale royalty.[38] For example, when recoverable reserves fall, (to 250 million cubic meters per square kilometer for the gas field) a 20% tax exemption is then enacted.[39]

The new tax rules will also require part of the tax revenues be redirected to local governments. Within local coffers, these revenues then compensate locals for any environmental or social issues resulting from petroleum operations.[40] By retaining petroleum revenues in the production region, both the shale gas company and the Chinese government acknowledge local interests and have the opportunity to augment their own public images. Nigeria's Movement for the Emancipation of the Niger Delta demonstrates

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[35] *Ibid.*

[36] Moser, Michael and Fu Yu. Doing Business in China. *London: Juris Publishing.* 2014.

[37] Ling, Song Yen and Irene Tang. "China to Raise Oil, Gas Upstream Resource Tax to 6% from 5% Starting Dec 1." *Platts*. 2014. http://www.platts.com/latest-news/natural-gas/singapore/china-to-raise-oil-gas-upstream-resource-tax-26901874.

[38] Ernst & Young, *op. cit.*

[39] Ministry of Commerce of the People's Republic of China. "Tax Law of the People's Republic of China and International Tax Guide." 2011. http://tax.mofcom.gov.cn /tax/taxfront/en/article.jsp?c=30113&tn=1&id=3b031329 1b 9e4ec893e4824a61a1f9c6

[40] Hogan Lovells International LLP. "China Resource Tax Reforms to Roll out Nationwide." 2011.

that diverting petroleum tax revenues to other regions or projects could instead fuel civil resentment towards the companies and government.[41]

Furthermore, shale gas firms can also apply for royalty tax exemptions with the government. In the future, the government will issue similar tax exemptions for firms paying the resource tax.[42]

PRODUCTION SHARING

The second half of Chinese shale gas contract is the Production Sharing Agreement (PSA), which China has employed in its upstream petroleum industry since the 1980s.[43] The PSA separates the rights and obligations of each party during each phase: exploration, development, and production. It also delineates petroleum production into "cost oil" and "profit oil", which in this case constitute shale gas. [44] In a PSA, the company is entitled to cost recovery through cost oil for current operating expenses, materials used in the year in which they are acquired, and for capital investment. In China, cost recovery is determined by the following expenses:

- Petroleum royalties (or resource tax for PSAs signed after 1 November 2011);
- Production and operations;

[41] Oyefusi, Aderoju. "Oil-dependence and Civil conflict in Nigeria." *University of Benin, Nigeria*. 2007.
[42] Ernst & Young, *op. cit.*
[43] Hove et al., *op. cit.*
[44] *Ibid.*

- Exploration;
- Development; and
- 9% deemed interest cost recovery on development costs.[45]

Cost recovery generally ranges from 50% to 60% for onshore PSAs.[46] The remainder oil, or profit oil, is then distributed between the company and the Chinese government based on the agreed percentage division. Therefore, China's PSA places all financial risks on the petroleum company during the exploration and development phases, but assures cost recovery once the project is deemed commercial. However, because of geological obstacles and low international petroleum prices, only Sinopec's Fuling project has achieved commercial production.[47]

A PSA's cost-recovery clause creates grey areas in which accountants might "gold plate" or inflate company expenditures to obtain a greater share of the gas produced at the expense of government take. Thus, China's PSA contract structure might inherently add distrust in the IOC-government relationship, harming cooperation between the two parties.[48] Since assuming power, President Xi Jinping has campaigned relentlessly against Zhou Yongkang's network and corruption in the national oil industry, which could expose

[45] Ernst & Young, *op. cit.*
[46] *Ibid.*
[47] Thomas, Mark. "Shale Fueled by Fuling on its Slow Boat to China." *E&P Magazine*. January 12, 2016. http://www.epmag.com/shale-fueled-fuling-its-slow-boat-china-833821#p=full.
[48] Radon, Jenik. "The ABCs of Petroleum Contracts: License-Concession Agreements, Joint Ventures, and Production-Sharing Agreements." 2005.

company gold-plating.[49] Most at risk are non-joint venture shale projects. Within a joint venture, either between an IOC and Chinese petroleum company or solely among Chinese firms, partners need to approve project expenditures and are unlikely to sanction excessive spending. Non-joint venture projects lack this constraint. The newly deregulated shale gas industry could receive significant suspicion and investigation under the anti-corruption campaign, which could harm the company-government relationship.

Furthermore, shale gas projects do not follow the same distinct phases (exploration, development, and production) associated with the conventional projects PSA. In shale gas projects, these three phases typically all go on simultaneously. Shale gas wells also deplete more quickly than conventional wells yet require a production period of around 30 years to become economic.[50] As a result, shale gas firms have fewer incentives to invest in Chinese shale blocks.

Another source of conflict is the PSA's environmental standard provision. PSAs typically incorporate contractual provisions for environmental standards. Because a contractual provision is more easily contested than a regulatory statute, if the company violates the provision it will only be required to privately rectify the breach. In contrast, if the agreement was a pure concession agreement and not a PSA, this would be a violation of a legal statute and subject to legislatively approved sanctions, penalties, and public

[49] Sheehan, Matt. "China Targets Big Oil in Wars on Corruption, Pollution." *Huffington Post*. 2015. http://www.huffingtonpost.com/2015/03/17/china-corruption-oil-coal-pollution-crackdown_n_6882690.html.
[50] Hove et al., *op. cit.*

condemnation.[51] Thus, in some cases, the China's PSA contractual structure might encourage environmental noncompliance.

TAX DEDUCTIONS AND DEPLETION

China does not operate a ring fence in its tax code. This allows a shale gas company to report its income tax on a consolidated basis for all PSA projects it owns in China. Therefore, companies can offset their losses in one project with gains in another, reducing their overall taxable incomes. Furthermore, China allows companies to carry forward net operating tax losses for five years to offset future taxable income.[52]

China also provides several tax deductions to incentivize investment and lengthen production timeframes. For example, exploration expenditures incurred can be either expensed against income from other fields that the company owns in China or can be capitalized. Similarly, development expenditures may be depreciated on a straight-line basis, subject to a minimum period of eight years from which commercial production began. Development expenditures include the costs for design, construction, installation, drilling, and their corresponding research work. Furthermore, research and development expenditures may be deducted from taxable income at 150% of their actual expenses.[53]

China, unlike the United States and France, does not employ a depletion allowance. A depletion allowance is a set tax break on operational expenditures in the exploration and production of non-renewable reserves, such as oil and gas. The untaxed revenues of the

[51] Radon, *op. cit*.
[52] Ernst & Young, *op. cit.*
[53] *Ibid.*

reserve are then directed towards further development once the shale gas company is finished extracting from a previous field.[54] Thus, a depletion allowance subsidizes the company's operations providing the government benefits such as prolonged employment, steadier production, and more long-term fiscal revenues from royalties or corporate taxes.

[54] Hennessee, Patrick, and Sean Hennessee. *Oil and Gas Federal Income Taxation*. CCH Publications. 2016.

SHALE GAS RIGHTS AND BIDDING

Recently, China implemented two policies which originally were intended to stimulate shale gas development, but have instead produced unanticipated results.

The first policy is the liberalization of shale gas bidding to several more actors. Many in China see the oligopoly structure of the oil and gas industry as counterintuitive for a shale gas revolution, which in the United States relied on competition and innovation. The MLR tendered a first round of shale gas block auctions in June 2011, inviting only six state-owned enterprises to bid for four blocks. These six companies are CNPC, Sinopec, CNOOC, a provincial oil company, and two state-owned coal bed methane firms. In September 2012, the Ministry of Land and Resources held a second round of auctions for 20 shale gas blocks, and made precedence by opening the auction to all domestic firms and international joint ventures. A total of 83 firms submitted bids and 16 firms won 19 out of the available 20 blocks.[55] Two private firms (Huaying Shanxi Energy, a subsidiary of Wintime Energy, and Beijing Taitantongyuan Natural Gas) won exploration rights in two of the blocks, becoming the first private enterprises in the PRC to enter the upstream petroleum industry. The remaining 17 blocks went to central and local state-owned

[55] Krupnick et al., *op. cit.*

enterprises.[56] [57] At first glance, the bidding policy was successful in diversifying the shale gas industry -none of the winning bidders in the second round were NOCs. Each auction winner earned the right to explore its block for three years and if it invests in exploration, it will also earn the right to develop the block. However, if it does not make the full work commitment, the company must relinquish a portion of the lease equivalent to the percentage of the work commitment not completed.[58]

The second policy is the State Council's 2011 classification of shale gas as a new type of mineral resource, separate from conventional gas. Because only NOCs have the right to produce conventional oil and gas resources, this decision now allows any company, including privately owned firms, to develop shale gas.[59]

Although these two reforms represent China's intent to liberalize the upstream oil and gas sector, smaller Chinese firms have had little success in shale gas development. First, it is acknowledged that most of the blocks auctioned off during the second bidding are remote and have worse subsurface geology and infrastructure than those distributed in

[56] The winning bidders include: Huadian Coal Industry Group; China Coal Geology Engineering; Huaying Shanxi Energy Investment; Beijing Taitan Gas Technology; Tongren City Energy Investment; Chongqing City Energy Investment; Chongqing Mineral Resources Development; State Development Investment Corp.; Hunan Huasheng Energy Investment and Development; Shenhua Geological Exploration; Huadian Engineering Group; China Coal Geological Engineering Corp.; Hunan Shale Gas Development; Huadian Hubei Power; Jiangxi Natural Gas Holdings; Anhui Energy Group; and Henan Geological Exploration and Mine Investment.

[57] Platts. "China Awards 19 Blocks to 16 Domestic Companies in Second Shale Gas Bid Round." *Platts McGraw Hill Financial*. January 21, 2013. http://www.platts.com/latest -news/natural-gas/singapore/china-awards-19-blocks-to-16-domestic-companies-6056324.

[58] Dawson, Michael, and Mark Sakeld. "Unconventional Resource Development in China." February 27, 2014. https://www.albertacanada.com/files /albertacanada/AIS-OG_psac-breakfast-presentation-february272014.pdf.

[59] Krupnick et al., *op. cit.*

the first auction.[60] Secondly, these blocks are areas not previously explored by the NOCs and had limited geological data. It is important to note that none of the auction winners in the second round have any experience in oil and gas exploration and development. Some of the bidders specialize in power generation or are energy investment firms, and some were established only months before the auction. With backgrounds in industries such as power and coal mining where revenue streams are ensured by the state and well known reserves, these companies might not fully incorporate risks prevalent in the shale gas industry, such as dry holes.[61] These firms also lack access to China's national shale gas R&D centers, which are operated by CNPC and Sinopec.[62]

Secondly, conventional oil and gas resources are still legally monopolized by China's NOCs. Because the contracts signed by the second round bidders include only shale gas rights and not the right to produce from any overlapping conventional oil or gas reservoirs, these firms are hindered in obtaining profits in the short-run. In the United States, firms like Mitchell Energy minimized any financial losses from risky shale gas operations because they operated in areas where shale formations overlapped conventional gas formations and they had the rights to both resources. These firms then had the option to produce from the shallower conventional formations to finance any setback in their deeper shale gas wells. Access to revenues from conventional reserves is all the more significant when the relative cost of a shale gas well is considered. Because of the folding

[60] Wang, Zhongmin. "Qiantu weibu de zhongguo yeyanqi rechao 前途未卜的中国页岩气热潮 [China's Elusive Shale Gas Boom]." *The Paulson Institute*. 2015.
[61] Zhou, Xizhou. 2013. "Shale Gas Revolution in China: Game Changer for Coal." *Wilson Center*. Woodrow Wilson Center.
[62] Krupnick et al., *op. cit.*

geography and road construction to transport machinery, the cost of drilling a shale gas well in the Sichuan Basin ranges from $11.3 to $12.9 million. In contrast, the average cost of a shale well in the Marcellus formation in the United States is around $7.6 million.[63] In China, nearly 80 percent of the most prospective shale gas reserves overlap with conventional oil and gas reserves. However the exploration rights to any overlapping conventional fields are legally monopolized by the NOCs.[64]

Overall, progress in the second round shale gas blocks has been slow. The first exploratory well was drilled on 5 December 2013, a year after the auction. By 2015, 400 wells have been drilled and geological surveys conducted in the blocks awarding during these two auctions, yet Sinopec's Fuling field remains the only big commercial find.[65] Because of the lack of commercial production from the second shale gas round, China's has yet to hold a third auction round.[66]

The relinquishment requirement in the shale gas contracts can also add risk to second round shale gas projects. Shale gas development is typically dispersed over large areas and relies on finding "sweet spots" in shale layers. The timeframe in which the commercial viability of a shale gas project can be determined is unpredictable. Thus, early relinquishments will not produce optimum results.[67]

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[63] "Chinese Buoyant about Shale Gas Prospects." *Shale Gas International*. October 27, 2015. http://www.shalegas.international/2015/10/27/chinese-buoyant-about-shale-gas-prospects/.
[64] Krupnick et al., *op. cit*.
[65] "China Struggles to Find Prospective Blocks for Third Shale Auction." *Reuters*. January 5, 2015. http://www.reuters.com/article/2015/01/05/china-shalegas-idUSL3N0TH35F20150105.
[66] "China Pushing Ahead with Shale While Falling Prices Dim Interest." *Bloomberg*. November 4, 2015. http://www.bloomberg.com/news/articles/2015-11-05/china-pushing-ahead-with-shale-while-falling-prices-dim-interest.
[67] Hove et al., *op. cit.*

Furthermore, data from well logs and other sources is crucial for the development of shale gas. Data in the United States plays an important role in directing producers with their limited capital towards the best opportunities. In China, access to data for shale gas operations is highly restricted by the NOCs. CNPC and Sinopec have no legal obligation to distribute their information from conventional onshore activities. In addition, oil and gas data have sometimes been protected by the government as state secrets.[68]

[68] *Ibid.*

MIDSTREAM PIPELINE ACCESS

Inadequate natural gas pipeline infrastructure as well as the lack of an open access policy are also hindrances to China's shale gas development. Without mid-stream access, upstream shale gas producers are unable to sell their product. However, China does not need to build a vast pipeline system to meet its 2015 and 2020 shale gas targets. In the short-term, shale gas will likely be distributed through the current, regional pipeline systems. For example, shale gas from the Fuling field is already transported to coastal customers through Sinopec's Sichuan-East Gas Transmission pipeline.[69] Beyond 2020, China will require more sophisticated pipeline networks to transport its shale gas from production sites to urban markets.[70]

In the United States, federal regulations exist that require open access, on a nondiscriminatory basis, to natural gas pipelines and storage facilities.[71] Pipeline tariff rates are available to any customer through the state regulatory commission. Furthermore, vertical separation of the petroleum industry in the United States limits one firms control over production, transportation, and sales.[72] However in China, 90% of the natural gas pipelines are owned and operated by CNPC alone.[73] There have historically been no regulatory authority to mandate CNPC provide pipeline access or tariff quotes to other companies. Because of the mismatched bargaining power, Chinese unconventional gas producers (among others) have found it difficult to reach transportation agreements with

[69] Sinopec, 2016.
[70] Hove et al., *op. cit.*
[71] *Ibid.*
[72] Krupnick et al., *op. cit.*
[73] Li, Yongming, Tao Liao, Hai Yang and Jinzhou Zhao. "China Accelerates Shale Gas Development." *Oil and Gas Journal* 112 (10). 2014.

pipeline operators and pay a higher premium if the NOCs are willing to negotiate.[74] However, reforms are underway in China's oil and gas pipeline management. In February 2014, the National Development and Reform Commission (NDRC) issued a new policy requiring operators of natural gas pipelines to provide unused capacity to new customers on a fair and nondiscriminatory basis. This policy is a signal with respect to breaking CNPC's pipeline monopoly. However, this is a limited open access policy in comparison to that in the United States. In the short-term, new shale gas producers only have open access to excess capacity not being used by existing customers and pipeline operators.[75]

[74] Chou, Ella. "Shale Gas in China – Development and Challenges." 2013.
[75] Hove et al., *op. cit.*

DOWNSTREAM PRICE REGULATIONS

Natural gas prices in China have historically been regulated throughout the value chain. Natural gas wellhead prices, pipeline tariffs, and end-user prices are all regulated by the National Development and Reform Commission (NDRC).

- Wellhead prices include a profit margin and are based on upstream production costs. Suppliers and buyers are free to negotiate increases of up to 10%.
- Pipeline tariffs are set based on three factors: cost, distance from the gas field to the city gate, and a profit margin set with an internal rate of return of 12%.
- End-user prices are set by the gas source and usage. For example residential, commercial, industry, or fertilizer use.[76]

Under these previous regulations, the government often sets the price of conventional natural gas and tight gas at levels below the equilibrium market price, resulting in shortages, low revenues, and a lack of innovation among gas suppliers.[77] In July 2013, the National Development and Reform Commission announced reforms toward market pricing. Prices for "new gas" (gas above 2012 consumption levels) for non-residential users are now linked to prices for fuel oil and liquefied petroleum gas. Additionally, in August 2014 the National Development and Reform Commission announced that the price of non-residential "old gas" will be increased by 0.4 RMB/cubic meter. Wellhead prices for shale gas has also been deregulated. Although city-gate gas

[76] Ibid.
[77] Wang, 2015, *op. cit.*

prices may still be subject to a price cap, shale gas producers now have an opportunity to obtain market-based profits from their business.[78]

Shale gas projects also benefit from Ministry of Finance (MOF) subsidies. Effective from 2013 to 2015, shale gas receives a 0.4 yuan per cubic meter ($2.30/MMBtu) subsidy, representing 21% of the average city gate price for natural gas in China. Most of the shale gas projects auctioned off are eligible for this subsidy.[79] Local governments can also subsidize shale gas production. China's national shale gas subsides were extended to 2018, but will be to 0.2 yuan per cubic meter from 2019 to 2020, as development costs fall.[80]

Since 2013, Chinese NOCs have reduced the cost to drill in the Sichuan Basin by 23%[81] through technologies and innovations such as Cluster Well Design and "Well Factory" production management.[82] Nevertheless, prices in China's shale gas market do not match competitive prices from alternatives. Even with subsidies, Fuling shale gas costs twice as much as LNG imports with average prices of $11.20/MMBtu[83] and $6.70/MMBtu respectively.[84] Furthermore, Fuling's costs are higher than the actual tariffs Sinopec receives for its shale gas. Only with a production of 6 billion cubic feet/day could Fuling

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[78] Hove et al., *op. cit.*
[79] Krupnick et al., *op. cit*.
[80] Bloomberg, 2015, *op. cit*.
[81] Aloulou, Faouzi. "Shale gas development in China aided by government investing and decreasing well cost." *EIA.* September 30, 2015. https://www.eia.gov /todayinenergy/detail.cfm?id=23152.
[82] Sinopec, *op. cit*.
[83] Glickman, Noemi. "China's Shale Gas Costs are at Least Double those in the U.S., but Rising Output will Aid its Bargaining Position in World Markets." *Bloomberg New Energy Finance*. May 29, 2014. http://about.bnef.com/press-releases/chinas-shale-gas-costs-least-double-us-rising-output-will-aid-bargaining-position-world-markets/.
[84] Wilson, Stephanie. "China's Nov LNG imports rise 3.5% on year to 1.8 million mt." *Platts*. December 28, 2015. http://www.platts.com/latest-news/natural-gas/singapore/chinas-nov-lng-imports-rise-35-on-year-to-18-27088446.

shale gas be economic with current tariffs and subsidies.[85] However, through their integrated supply chains, Chinese NOCs can finance these costly projects and benefit from long-term cost declines. Furthermore, despite cuts to capital budgets, CNPC and Sinopec are redirecting investment away from oil exploration and into upstream gas, including Sichuan's shale projects.[86]

[85] Glickman, *op. cit.*
[86] Zhou, Oceana. "China's Sinopec Pushes Gas Output Plan as Oil Languishes." *Platts*. April 12, 2016. http://www.platts.com/latest-news/natural-gas/singapore/feature-chinas-sinopec-pushes-gas-output-plan-27454734.

MULTIPLE REGULATORS

Shale gas operators must coordinate several aspects of their operations with a complex matrix of Chinese regulators. The National Development and Reform Commission (NDRC) shapes overall policy and decides natural gas prices. The National Energy Administration (NEA) sets shale gas production targets. The Ministry of Land and Resources (MLR) conducts bid rounds. The Ministry of Finance (MOF) determines shale gas production subsidies. The Ministry of Science and Technology (MOST) funds shale gas technology research and development. The Ministry of Environmental Protection (MEP) sets rules to protect air and water quality.[87] The Ministry of Commerce (MOFCOM) previously was the authority for reviewing and approving foreign PSAs, however the 2013 State Council Decree No. 638 legislated that PSAs need only be filed with the ministry's local counterparts.[88]

The existence of such a large bureaucratic network with overlapping jurisdictions creates coordination issues in shale gas policy. For example, both the Ministry of Environmental Protection and Ministry of Land Resources produce groundwater protection policy and if interagency communication is unclear, the shale gas developer does not know which policy to follow. Investment in shale gas proceeds more slowly than in a simpler bureaucracy because companies that are approved by one ministry might remain unsure if they require approval from another.[89] Furthermore, the resource base and enforcement capacity of each agency varies, giving some agencies greater weight in shale gas policy

[87] Li et al., *op. cit*.
[88] Ministry of Commerce of the People's Republic of China. "Zhonghua renmin gongheguo guowuyuan ling di 638 hao 中华人民共和国国务院第638号 [State Council Decree No. 638]." 2013. http://www.mofcom.gov.cn/article/b/g/201311/20131100381779.shtml.
[89] Hove et al., *op. cit.*

than their official authority.[90] Although collaboration on policy issues among the ministries have improved recently, these are important challenges for foreign IOCs, some of which report a lack of clarity concerning the roles of Ministry of Environmental Protection, National Energy Administration, and National Development and Reform Commission.[91] Similarly, the release of new policies and regulations in China is often opaque, while giving IOCs inadequate input to the process or time to prepare for chances.[92]

[90] Eastin, Joshua and Ka Zeng. Greening China: The Benefits of Trade and Foreign Direct Investment. *University of Michigan Press*. 2011.
[91] Hove et al., *op. cit.*; Zhou, 2013, *op. cit*.
[92] U.S. Trade and Development Agency, 2014, *op. cit.*

ENVIRONMENTAL CHALLENGES

Shale gas producers must also maintain high standards in environmental protection and overcome public opposition from a growing environmental awareness. As a result of China's environmental degradation from rapid industrialization, the environment is becoming a significant topic in Chinese public dialogue.[93] In 2011, as a response to protests against a petrochemical project in Ningbo, cabinet members passed a requirement that any onshore or offshore project must now pass both a "social risk" test in addition to an environmental impact statement.[94]

At the same time, China's growing water stress is drawing criticism to water-intensive industries, such as shale gas.[95] Shale gas energy production can add to water stress not only through hydraulic fracturing, but also through the steam turbine in the natural gas power plant. However, as seen in Figure 2, water consumption in coal power generation is significantly higher than that in shale gas generation, due to greater water usage in flue gas scrubbing and power plant cooling. As a result, fuel switching from coal to shale gas in energy production could reduce China's overall water demand.[96]

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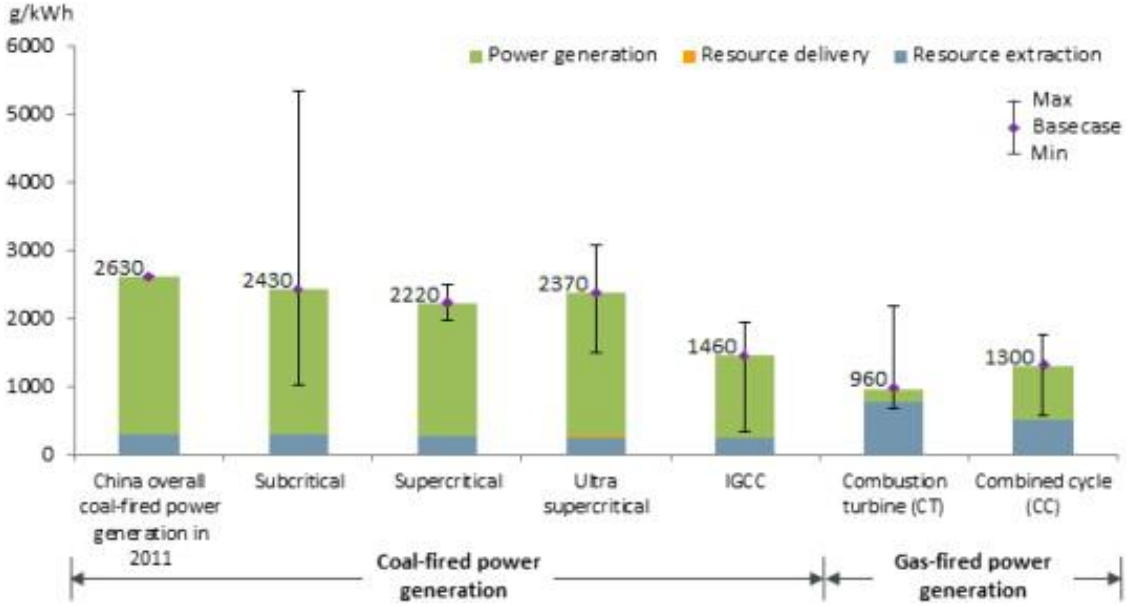
[93] Guo, Xiumei, and Dora Marinova. "Environmental Awareness in China: Facilitating the Greening of the Economy." *Curtin University Sustainability Policy Institute*. 2011.
[94] Redden, Jim. "Regional Report: China." *World Oil Journal* December 2012: 80-87.
[95] Tiezzi, Shannon. "China's Looming Water Shortage." *The Diplomat*. 2014. http://thediplomat.com/2014/11/chinas-looming-water-shortage/.
[96] Chang, Yuan, Runze Huang, Eric Masanet, and Robert Ries. "Life-cycle comparison of greenhouse gas emissions and water consumption for coal and shale gas fired power generation in China." *Elsevier*. 2015.

Figure 2: Water Consumption of 1 kWh Coal- and Shale Gas-fired Electricity in China[97]



Furthermore, because a majority of China's current shale projects are in the water-rich Sichuan Basin, water-stress will not become a significant issue within the industry until development begins in drier regions such as Xinjiang or the Northeast.[98]

Shale gas production also recovers significant quantities of fracturing fluid flow back and produced formation water which must be treated and safely disposed. China's current regulations do not permit Class II injection wells, through which operators can reinject brines for long-term storage.[99] Instead, operators must expensively truck brine to off-site

[97] *Ibid.*
[98] Calow et al., *op. cit.*
[99] U.S. Trade and Development Agency, 2014, *op. cit.*

evaporation ponds for water disposal, raising government concerns for contamination of local farmlands.[100]

China also lacks seismic regulations for shale gas projects. Especially in the Sichuan Basin, which is already seismically active, hydraulic fracturing poses a threat when conducted along a fault zone. For example, mild earthquakes can deform the well casing and cement, allowing contaminated fluids to migrate up into drinking water aquifers.[101]

Furthermore, the climate and economic benefits of shale gas depend on methane leakage rates. Shale gas can escape into the atmosphere during exploration, venting, flaring, production, transmission, and storage. Once in the atmosphere, methane is 84 times more powerful a greenhouse gas than CO_2 over a 20-year period. For example, the 2015 SoCalGas storage facility leak cost the company 62 million cubic feet of methane each day and accounted for a quarter of California's total greenhouse gas emissions.[102] Therefore, if China hopes to reduce its greenhouse gas emissions through fuel switching from coal to shale gas, it must minimize methane leakage. However, methane leakage rates are relatively low in China. For example, in 2012 China's methane leakage was only 6.4 MT CO_2e and 0.1% of its greenhouse gas emissions, compared to the U.S. with 192 MT CO_2e

[100] Feng, Yinsheng, Nianyin Li, Pingli Liu, Zhifeng Luo, and Liqiang Zhao. "Technical Status and Challenges of Shale Gas Development in Sichuan Basin, China." *Southwest Petroleum University*. January 29, 2015.
[101] Zhou, 2013, *op. cit*.
[102] Brownstein, Mark. "California's mammoth methane leak shows climate risks of natural gas." *Chinadialogue*. January 25, 2016. https://www.chinadialogue.net/article/show/single/en/8561-California-s-mammoth-methane-leak-shows-climate-risks-of-natural-gas.

and 3.4%.[103] China's methane leakage is also disproportionately small when relative production is factored in (China's 2012 natural gas production was 109 TCF/year compared to the U.S.'s 300 TCF/year).[104] This implies China's low methane leakage could be due to the younger age of its natural gas infrastructure. Unlike the United States, however, China does not publish its methane leakage data regularly or separate it into stages of production which can discredit the country's monitoring capabilities.[105]

[103] Delgado, Michael, Kate Larsen, and Peter Marsters. "Untapped Potential: Reducing Global Methane Emission from Oil and Natural Gas Systems." *Rhodium Group*. April 2015.
[104] BP. "BP Statistical Review of World Energy June 2013." *British Petroleum*. June 2013. http://www.bp.com/content/dam/bp-country/fr_fr/Documents/Rapportsetpublications/statistical_review_of_world_energy_2013.pdf.
[105] Delgado et al., *op. cit.*

INTERNATIONAL COOPERATION

While Chinese NOCs privately engage IOCs and service companies, the Chinese and U.S. governments also promote technology exchange and knowledge transfer within the shale gas sector. Tapping China's domestic shale gas is particularly appealing to the U.S. because it promotes global greenhouse reduction efforts, energy security, and economic development.[106] Established in 2009, the U.S.-China Strategic and Economic Dialogue facilitates cooperation among shale gas industrial and government leaders through several programs:

- U.S.-China Shale Gas Resource Initiative;[107]
- Energy Cooperation Program (Shale Gas Working Group);[108]
- U.S.-China Oil and Gas Industry Forum; and[109]
- U.S.-China Climate Change Working Group.[110]

For example, in 2014 the U.S. Trade and Development Agency (TDA), under the U.S.-China Climate Change Working Group, hosted eight Chinese public sector representatives

[106] Forbes, Sarah, Jonathan Moch, and Xiaoliang Yang. "3 Ways the US and China Can Work Together for Responsible Shale Gas Development." *ChinaFAQs*. March 20, 2014. http://www.chinafaqs.org/blog-posts/3-ways-us-and-china-can-work-together-responsible-shale-gas-development.
[107] The White House. "Fact Sheet: U.S.-China Shale Gas Resource Initiative." November 17, 2009. http://www.chinafaqs.org/files/chinainfo/US-China_Fact_Sheet_Shale _Gas.pdf.
[108] U.S. China Energy Cooperation Program. "Shale Gas Working Group." *ECP*. 2013. http://www.uschinaecp.org/WorkingGroups/ShaleGas.aspx.
[109] "15th U.S. – China Oil and Gas Industry Forum." *United States Energy Association*. 2015. https://www.usea.org/event/15th-us-china-oil-and-gas-industry-forum.
[110] U.S. Trade and Development Agency. "USTDA Celebrates U.S. Industry's Support of the U.S.-China Climate Change Working Group." *USTDA*. June 26, 2015. https://www. ustda.gov/news/press-releases/2015/ustda-celebrates-us-industry%E2%80%99s-support-us-china-climate-change-working.

from the Ministry of Land and Resources, Ministry of Environmental Protection, Chongqing Development and Reform Commission, Sichuan Province Resource Administration, National Energy Administration, and National Energy Shale Gas R&D Center. During the trade mission, the delegation toured Marcellus and Barnett shale operations and met with representatives from DOE, EPA, ExxonMobil, Newark Energy, Baker Hughes, the Texas Railroad Commission, and the Texas Commission on Environmental Quality as well as other parties. Overall, there is great interest among the Chinese delegation of promoting the role of small and medium size shale gas developers, market oriented gas pricing policies, rural and urban production, wastewater reinjection practices, and seismic regulations.[111] A similar TDA workshop was held this March in Yibin, Sichuan and networked U.S. service and equipment suppliers with prospective buyers hand-picked by the National Energy Administration.[112] For example, Harcros Chemicals marketed its energized fracking fluid technologies in development which through a CO_2 or N_2 foam, viscoelastic surfactant, and nanoparticles can significantly reduce the water resources needed to stimulate a formation.[113] In order to ensure a downstream market for shale gas, the Yibin workshop also invited transport and electricity companies to participate. In May 2014, the U.S. Department of State and MLR also

[111] U.S. Trade and Development Agency, 2014, *op. cit*.
[112] Gas Technology Institute. "Advances in Natural Gas Utilization and Production Workshop." *GTI.* 2016. http://www.gastechnology.org/Training/Pages/US-China-Natural-Gas-Workshop-Proceedings-March-2016.aspx.
[113] Wang, Ruijia. "How Surfactant is Changing the Shale Revolution." Hacros Chemicals. 2016. http://www.gastechnology.org/Training/USChinaShaleWrkshps/March2016 /Harcros-Ray-Wang-Shale-Panel-Mar2016-EN.pdf.

organized their first regulatory and tendering/contracting workshop through the U.S.-China Climate Change Working Group.[114]

Although these dialogues include a diversity of U.S. petroleum and service companies, China's industry participation is dominated by the NOCs and disadvantages the newer, smaller shale gas firms. For instance, the Energy Cooperation Program's Energy Financing and Investing Working Group and the China Industrial Overseas Development and Planning Association (CIODPA) will implement activities that provide Chinese and U.S. executives with decision-making tools to promote energy investment partnerships. [115] However, of CIODPA's member enterprises, only one is a winning bidder of the second shale gas bid (Shenhua Group). A majority of CIODPA's member enterprises are large SOEs, including CNPC and Sinopec, which will benefit directly from the program's investment arrangements.[116]

[114] U.S. Department of State. "U.S. – China Strategic and Economic Dialogue Outcomes of the Strategic Track." *Embassy of the United States, Beijing*. July 14, 2014. http://beijing.usembassy-china.org.cn/2014/u.s.-china-strategic-and-economic-dialogue-outcomes-of-the-strategic-track.html.
[115] U.S. China Energy Cooperation Program, *op. cit*.
[116] China Overseas Development Association. "Member Enterprises." *CODA*. 2015. http://coda.chinagoabroad.com/en/pages/list/hydw.

RECOMMENDATIONS

China's shale gas policy is successful in developing a nascent industry. Nevertheless, several features of the contractual, regulatory, and market systems so that when petroleum prices and investment activities rebound, China can efficiently produce its vast reserves. Therefore, the following initiatives are recommended:

1. **Remodel the Production Sharing Agreement:** Chinese policy makers should produce a model PSA contract for shale gas projects. Shale gas projects do not follow the same distinct phases associated with conventional projects and their PSAs require production periods of around 30 years. A model shale gas PSA will also clarify the likely structure of the commercial deal and reduce the cost of contract negotiation. Because coal bed methane projects exhibit similar phases as shale gas projects, Chinese policy makers can retrofit provisions from China's coal bed methane (CBM) PSA to develop a more efficient shale gas PSA. For example, the onshore CBM PSA does not contain relinquishment obligations and could give the shale gas firm sufficient time to develop commercially attractive flow-rates within the block. Furthermore, the CBM PSA includes a Pilot Project Stage, which allows the firm to evaluate potential returns from the shale gas block before committing to full-scale development. Finally, commerciality and cost recovery in

the PSA should be determined gradually in the course of exploitation and should be approved by sub-areas of the block, not the block as a whole. [117]

2. **Implement a Depletion Allowance:** A depletion allowance will promote China's shale gas development, encouraging employment and generating more fiscal revenues over the long-run. Similar to France's depletion code, China should require its depletion allowance to only be re-invested in Chinese territories to ensure depletion allowance funds finance domestic rather than foreign projects. Depletion allowances can be determined through cost depletion and the government can extend an additional percentage depletion option to independent shale gas firms. Thus, projects can more rapidly progress from the development phase to commercial production and be eligible for PSA cost recovery.
3. **Maintain Petroleum Tax Revenues within the Production Region:** Government redistribution of petroleum tax revenues for local education, health, or environmental projects not only compensates local populations for costs associated with petroleum production, but also legitimizes the relationship between the government and the petroleum company. China's resource tax is a step in this right direction. Chinese policy makers and companies should further engage the public with programs funded by the local petroleum operations. For

[117] Hove et al., *op. cit*.

example, Shell China's volunteers regularly hold safety education programs at Sichuanese schools[118] and the company's "New Economy China Project" helps finance local green industries.[119] Similarly, Chinese NOCs are also becoming involved in the local community through welfare construction and public education.[120] These projects present the company as not just as an economic partner but also as a social partner.

4. **Manage Environmental Impacts:** Chinese shale gas companies and IOCs should continue promoting shale gas as a cleaner and less water intensive alternative to coal while minimizing any environmental hazards, such as methane leakage or water pollution. Methane leakage from shale gas production significantly reduces the greenhouse gas benefit of fuel switching from coal to gas. Thus, shale gas companies can use public relations to show a mutualistic relationship between themselves and environmental regulators by adopting mandatory Reduced Emission Completion (RECs) and annual public disclosure of methane emissions. Adequate maintenance and monitoring of natural gas infrastructure will minimize

[118] Shell China. "Jinqiu xiangmu guanzhu ertong anquan changdao anquan wenhua zoujin xiaoyuan金秋项目关注儿童安全 倡导安全文化走进校园 [The Autumn Project Pays Attention to Children Safety, Introducing a Safety Culture to Campus]." *Shell*. March 28, 2014. http://www.shell.com.cn/zh/environment-society/community/community-care/talks-to-community-kids-for-road-safety-20140328.html.

[119] Shell China. "2014 Lvse chuangyehui – ji Qiaopai shehui touzi xiangmu 'xinjingji zhongguo' zouguo shinian 2014绿色创业汇--记壳牌社会投资项目"新经济中国"走过十年 [2014 Green Entrepreneurship Exchange – Marks 10 Years of Shell's Social Investment Program, 'New Economy China.'" *Shell*. May 16, 2014. http://www.shell.com.cn/zh/environment-society/community/development/green-ventures-gathering-20140516.html.

[120] Sinopec, *op. cit*.

methane leakage in China's younger infrastructure. Similarly, shale gas firms can minimize methane leakage during wellhead operations through technologies such as green completions, plunger lift systems, desiccant dehydrators, dry seal systems, and pneumatic controllers.[121] Furthermore, seismic and water treatment regulations should be designed to complement a safe and economic shale gas industry.

5. **Build Regulatory Capacity and Reduce Regulatory Overlap:** Improving coordination and regulatory capacity among ministries will promote environmental compliance and relieve petroleum investors of regulatory uncertainty. China should also publish a joint guide detailing all regulatory approvals required for shale gas investments. Similar guides have successfully summarized regulatory steps and responsibilities in the United States.[122] Furthermore, China should formulate environmental regulations on wastewater injection practices and seismic monitoring.
6. **Incorporate Second Round Shale Gas Firms in International Partnerships:** Because second round block winners are new to the shale gas industry and have limited capital, there is a significant need for technology transfer from U.S. joint ventures and service providers. However, China's participation in international shale gas technology and practices programs is monopolized by the NOCs. Giving

[121] Harvey, Susan, Vignesh Gowrishankar, and Thomas Singer. "Leaking Profits." *NDRC*. March 2012.
[122] Hove et al., *op. cit*.

second round producers a seat at international partnerships and research programs can gradually train them in upstream development, adding a competitive force to China's shale gas industry.

7. **Relegate Shale Gas Development to either Oligopolistic NOCs or Decentralized Companies**: China should either further deregulate its petroleum industry or rely on its NOCs for shale gas development. Policy makers should not spend resources on maintaining the status quo. Chinese NOCs have experience in hydraulic fracturing and horizontal drilling, diversified operations, foreign joint venture support, and complete control over conventional reserves. This leaves China's smaller shale gas firms at a disadvantage, unless policy makers drastically reform China's petroleum industry. The shale gas revolution in the United States is attributed to several small, competitive firms that reduced costs through breakneck innovation. However, any Chinese shale gas revolution will start with CNPC or Sinopec unless the entire natural gas value chain is deregulated.

CHINA'S NOC SHALE GAS REVOLUTION

Given current shale gas policies, it appear that China's NOCs will be the source any shale gas innovation. Sinopec and CNPC have vast experience in developing tight gas, through which they have acquired advanced technologies in horizontal drilling and hydraulic fracturing that can be transferred to shale fields. Secondly, these two firms own the exploration rights to the most promising shale gas blocks in China. Thirdly, China's NOCs have access to international industrial programs. They also have the financial capacity to invest in North American shale gas blocks and transfer production and managerial ability to their own projects in China. The NOCs control most of China's oil service firms and natural gas pipelines, ensuring access to upstream equipment and downstream markets. They are also large enough to take on financial risks and can subsidize shale gas development with their conventional production. At the same time, NOCs have strong political capital, and can more effectively adopt industry regulations and conduct public relations with customers. Under these circumstances, China's shale gas revolution will be a far different from North America's, and will likely be spearheaded by Sinopec and CNPC.

Appendix: List of Interview Subjects by Date (Anonymized)

1. Western oil company official, Houston, April 4, 2016
2. Western oil company official, Houston, April, 4 2016
3. Academic analyst, Houston, April 4, 2016
4. Western oil company official (via telephone), Beijing, April 5, 2016
5. Western oil company official (via telephone), Houston, April 6, 2016
6. Western oil company official (via telephone), Oklahoma City, April 9, 2016
7. Western oil company official (via telephone), Houston, April 11, 2016
8. Government official (via telephone), Washington, DC, April 11, 2016
9. Energy consultant (via telephone), Beijing, April 14, 2016
10. Energy consultant (via telephone), Hong Kong, April 17, 2016

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